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Unpacking the Functionality of Indigenous Knowledge Systems (IKSs) in Weather Forecasting in Turwi Basin, Zimbabwe

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***A*bstract**

Turwi Basin, whose primary source of livelihood is agriculture, straddles the two contiguous districts of Bikita and Zaka, south-east Masvingo Province, southern Zimbabwe. The greater part of the basin covers a drought-prone to dry agro-ecological region. Weather forecasting and the dissemination of weather information is done by the Meteorological Services Department of Zimbabwe, however, changing weather patterns are affecting weather forecasting reliability yet there are few weather stations in the basin while few households have access to weather forecast information. Gained through a long period of observation of the environment by local people, indigenous weather forecasting knowledge is site-specific, cheap and can fill in the gap that is left by scientific forecasting. The research study sought to identify the different indigenous weather forecasting knowledge indicators used in the basin and the role IKSs play in guiding farmers in agricultural planning**.** Participatory Rural Appraisal (PRA) methods were used to collect primarily qualitative data which were subsequently analysed using the thematic approach. Results show that weather forecasting IKSs are well-known in the basin and a majority of the basin farmers depend on them for planning their agricultural activities.

IKSs can be integrated with scientific weather forecasting to provide more accurate forecast information to the subsistence basin farmers thus helping them plan their activities and possibly improve food security therein. Validation of indigenous knowledge against scientific knowledge should be done over a long period of time. There is need to document IKS and teach it to young people as currently it is the preserve of older generation.

Key Words: indigenous knowledge systems, weather forecast, reliability, climate change and variability, food security.

Introduction

Literature tells us that the global climate including that of Africa is warmer than it was a century ago. According to Hulme et al., (2001), climate change will exert additional pressure on water resources with potentially disastrous consequences. Hoffmann, (2011) posits that climate change might diminish total agricultural production in many developing countries by up to 50% in the next few decades, mainly South Asia and sub-Saharan Africa. Agriculture in Africa largely depends directly on rainfall and perhaps 89% of cereals in sub-Saharan Africa are rain-fed (Cooper, 2004). Rainfall is highly variable in Africa, therefore it is essential to have a dependable weather forecast yet there are few weather stations. A reliable forecast enables farmers to plan the kind of crops that will be appropriate for the forecast conditions. Most of Africa's population is directly employed in agriculture, particularly the smallholder sector. In Zimbabwe for example, over 60% of the population lives in rural areas where they subsist on smallholder farming. Alvera (2013) concurs with Speranza (2009) that the problem of climate change and variability should be addressed from various angles and using different methods. Such an approach may probably achieve effective mitigation and adaptation. One such an approach is using indigenous knowledge (IK) in forecasting weather, especially at local level, considering that in Zimbabwe scientific forecasting is done over large areas usually over 9 000km^2 (Githungo et al., 2009) and longer time periods. Modern forecasts are made at very low spatial resolutions and focus is on rainfall amounts rather than on the timing of the rains, which is of greatest importance to the farmers. The IKSs approach might contribute to climate change monitoring, mitigation and adaptation. Presently, science is incapable of reliably predicting both the duration and distribution of seasonal rainfall. Modern scientific forecasts are usually issued for a period of one, three or six months and suggest the total amount of rainfall expected over that period, but not the distribution of rainfall within that period (Githungo et al., 2009). Therefore, complementing scientific forecasts with indigenous knowledge-based forecasting offers prospects for some inferences in this regard (Roncoli et al., 2002).

Manatsa (2012) notes that in Zimbabwe, forecasts issued by the Meteorological Services Department through the Southern African Regional Climate Outlook Forum (SARCOF) process generally had limited value to farmers. This calls for efforts to investigate other options like IKSs, and integrate them with modern scientific weather forecasting. The use of IKSs in weather forecasting in Zimbabwe has been explored by several authors (e.g. Muguti and Maposa, 2012; Shoko, 2012; Risiro et al., 2012; Makwara, 2013; Alvera, 2013) in the Chivi and Chimanimani , Mberengwa, Zaka and Mbire Districts respectively and small scale farmers were found to be rich in IKS (92%) (Makwara, 2013).

Research problem

In Turwi Basin, south-east of both Masvingo Province and Zimbabwe, rain-fed agriculture is the main livelihood activity. High rainfall variability, frequent droughts and severe dry spells are a common occurrence in the basin and these factors have a strong negative influence on agricultural yield thus increasing food insecurity (Bosongo, 2011). A combination of high dependence on rain-fed agriculture while rainfall is highly variable with recurrent droughts leaves the community vulnerable to food shortages (Muhonda, 2011). At the same time, the frequency of mid-season dry-spells has increased during the cropping season. For the period 1988 to 2011, rainfall had a coefficient of variation of 162% (Bosongo, 2011), resulting in yield being significantly reduced. Food security remains a challenge in the basin because of drought which occurs at least 5 out of every 10 years (LGDA, 2009). Farmers in Turwi Basin do not have a reliable form of forecast, making planning a challenge, often resulting in poor harvests even when normal rainfall is received. The Meteorological Services Department (MSD), through the SARCOF process, is responsible for issuing seasonal weather forecasts. These forecasts are given over large spatial scales as already indicated and focus on rainfall amounts only, disregarding intra-seasonal variability. Meanwhile, modern scientific weather forecasts may not be accurate all the time because of their probabilistic nature (Agrawala et al., 2001). The extent to which indigenous knowledge is used in forecasting weather in Turwi Basin is not fully known. Moreover, indigenous knowledge is in danger of being lost because it is the elderly people who possess it and has not been recorded, but merely orally passed from one generation to the other.

Objective

The objective of this study is to explore how indigenous weather forecasting indicators are used by Turwi Basin communities to help them plan their farming activities. This should be understood against the backdrop of a growing population and changing climate both of which demand and dictate an improvement in food security. Consequently, it is necessary to establish the role of indigenous knowledge systems in food security under changing climate conditions at local basin level.

Scope and limitations of the study

This study seeks to establish how indigenous weather forecasting helps farmers plan their farming activities thus increasing food security in Turwi Basin. Therefore, it identifies the various indigenous biotic and meteorological forecasting knowledge indicators for the coming season.

Impact of climate change and variability on agriculture

The Intergovernmental Panel on Climate Change (IPCC, 2007) proclaims that there is now little doubt that human-induced climate change is happening. It proceeds to report that variability is expected to increase with more rain falling in intense-rainfall events, larger year-to-year variations in precipitation in areas where increased mean precipitation is projected. Production in agriculture and therefore access to food and food security in most of the developing world is predicted to fall significantly as a result of changes in climate. Climate change and variability are likely to reduce the area that is suitable for agriculture, the length of the growing season and yield potential, especially along the boundaries of semi-arid and arid areas. This has the potential to worsen the food security situation in such continents as Africa and Asia. The IPCC (2007) notes that yield from rain fed agriculture in some developing countries, could fall by up to 50% by 2020 IPCC. The scenario painted above calls for adaptation to the changing climate conditions and this can best be achieved through improved weather forecasting.

The predicted climate change impacts on Africa can possibly cause food and water supplies to become more erratic, thereby increasing the incidence and gravity of droughts, storms and flooding in low-lying coastal areas. As Brown et al., (2007) note, key resources may become scarcer hence undermining livelihoods, triggering an overall decline in the quality of life. This makes research that explores responses and adaptation to environment change be a high priority in such regions as southern Africa, where the climate is highly variable and is likely to become more variable and extreme in the future (Ziervogel and Calder, 2003).Already rainfall patterns are showing signs of shifting as seasons are starting late and ending early while annual rainfall seems to be decreasing throughout southern Africa. Brown et al., (2007) postulate that annual rainfall is likely to decrease throughout most of the region with the exception of eastern Africa, where it is anticipated to increase. Burton (2001) estimates that in sub-Saharan Africa, anticipated effects of climate change in dry land areas include reduction in rainfall, rise in temperature, and increased rainfall variability.

Climate is the primary determinant of agricultural productivity (Adams et al., 1998) and is already a key driver of food security in many parts of Africa (Clover, 2003; Gregory et al., 2005). The most critical climate variables to measure with regard to food systems are temperature and precipitation. Climate change may directly or indirectly affect food systems in several ways (Gregory et al., 2005). Yet African agriculture is already under stress attributable to the growing population, economic and social development and the attendant increasing demand for and degradation of resources among others (Ludi, 2009). In the semi-arid regions of Africa, agriculture is centred on smallholder farming (systems) with an important multi-purpose livestock component yet these farming systems are vulnerable to climate (Challinor et al., 2007).

Climate-related shocks manifested by extreme weather conditions have destroyed livelihoods and exacerbated Africa's food insecurity, resulting in widespread hunger (Armah et al., 2013). Nelson (2004) states that climate affects all facets of rural life, including income and food security, and often exacerbates environmental degradation, with downstream effects on national economies. Many households in southern Africa depend on rain-fed agriculture for their food needs yet farming is commonly regarded as a risky venture with low earnings (Ziervogel and Calder, 2003). Food insecurity is likely to increase under climate change, unless early warning systems and development programs are used more effectively (Brown and Funk, 2008). Farmers in semi-extensive zones which are particularly sensitive to changes in climate are already vulnerable in terms of self-sufficiency and food security, and they are expected to be further marginalized due to increased risk of crop failure (Kurukulasuriya and Rosenthal, 2003).

Food security in Africa

Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life (FAO, 1996). Food security is anchored on four pillars namely availability, access, utilization and stability (FAO, 1996). Armah et al. (2013) observe that Africa keeps falling in and out of food crises and food insecurity, causing serious social and economic hardships for many communities and countries. Africa is worse-off than the rest of the world, scoring highly on the Global Hunger Index and recording low production (Armah et al., 2013). The first millennium development goal (MDG 1) seeks to eradicate extreme poverty and hunger and Zimbabwe is one of those countries that are not able to meet this goal. Since the launch of the fast track land reform programme around 2000, Zimbabwe has continually registered a food grain deficit. It was estimated that for the 2013/14 consumption season, Zimbabwe faced a cereal deficit of 870, 000 metric tonnes due to a poor rainfall season (ZimVAC, 2013).

Weather forecasting and its importance

Weather information is usually given as seasonal forecasts, which can be described as the total amount of rainfall expected during the season or over a given time period (Ziervogel and Calder, 2003). Most rain in southern Africa is brought by the Inter-tropical Convergence Zone (ITCZ), which is a region characterized by much convection activity resulting in rainfall during summer months (O'Brien and Vogel, 2003). The reliability and potential utility of weather forecasting information varies according to geographical region, that is, the area’s position in relation to oceanic atmospheric circulation, and according to the political, economic, and social context that shapes its dissemination and application (Orlove and Tosteson 1999 cited in Roncoli et al., 2002).

Weather forecasting can potentially increase preparedness and lead to improved social, economic and environmental outcomes within agricultural production systems. Several farm-level decisions hinge on the nature of rainfall variability or the prediction of climate variables for a specific year (Githungo et al., 2009). These include the choice of crop, the period for planting, whether and when to invest in which agro-chemicals, appropriate choice of plant population density all of which are associated with maximum production or minimum risk. Therefore weather forecasting is crucial so it is a must in agriculture.

Weather forecasting technically provides prospects for farmers to adopt improved technology, intensify production, replenish soil nutrients and invest in more profitable enterprises when climatic conditions are favourable and to more effectively protect their families and farms against the long-term consequences of adverse extremes (Vermeulen et al., 2010). Crop production in Zimbabwe is predominantly rain-fed and seasonal rainfall is highly variable, making crop failure due to rainfall extremes common (Martin et al., 2000). Improvement in weather forecasting and therefore advance warning systems of extreme weather events should be given priority, especially considering the resource-poor farmers, who are the most vulnerable group of the southern African region (Manatsa et al., 2012). The most useful forecast information, according to the farmers, are the early warning on anticipated poor season, the commencement of the season and adequacy of anticipated rains (Phillips, 2001). Droughts are the most common type of natural disaster in Africa and the problem is compounded by their complexity. The agriculture sector still forms the backbone of most economies in Africa, with 70% of output being derived from rain-fed small-scale farming. But the farming sector is the foremost casualty of droughts. Accurate, timely and relevant drought predication information enables a community to anticipate and prepare for droughts, hence minimize the negative impacts (Marinade and Bagula, 2012). Luseno (2003) suggests that indigenous climate forecasting methods can offer insights to improving the value of modern seasonal forecasts for pastoralists in East Africa since indigenous predicting methods are need-driven, focus on the locality, on the timing of rains, and indigenous forecasts are 'communicated in local languages and typically by "experts" known and trusted by pastoralists'.

Limitations of seasonal climate forecasts

Seasonal climate forecasts are normally issued for relatively large homogeneous rainfall regions (over 9,000 km^2) extending over three month period, making demarcation difficult for users located on the border line of the forecast spatial coverage since the forecast changes drastically each time (Githungo et al., 2009). Furthermore there is a mismatch between farmers' needs and the scale, content, format, or accuracy of available information products and services. These factors have limited the widespread use of seasonal forecasts among smallholder farmers (Vermeulen et al., 2010). In a study carried out by Manatsa et al., (2012) in Chiredzi district, farmers expressed great concern regarding the seasonal rainfall forecasts and were very sceptical of the value of these forecasts resulting in a very low rate of utilization (17%) among local smallholder farmers. The forecast skills are both very low and heavily biased towards near normal to normal conditions. Manatsa et al., (2012), also note that climate variability over short distances inherent in the Chiredzi area, even within villages, reduces the utility of forecast information, especially when provided at the current, national scale. The length of the season is very vaguely implied in the forecast, if defined at all, explaining the absence of the definition of other intra-seasonal variations in the forecast information, such as the distribution of both wet and dry spells, including their spatial distribution (Githungo et al., 2009; Manatsa et al., 2012). Various studies on uptake of seasonal climate forecasts have been done in Zambia, Zimbabwe, Kenya and Tanzania, and it has been found that it is hard for farmers, traditional leaders and agricultural extension officers to interpret forecast information given in probabilities and know how to respond to them (IDRC, 2010).

Study area

The Turwi Basin is located in the far south-eastern part of Masvingo province, where it forms a border with Manicaland province. It lies in the Lower Save Catchment, covering approximately 4,700 km^2. Going by the relatively large homogeneous weather forecasting regions (over 9,000 km^2), it means that the entire basin has one official meteorological station which is situated at Bikita Office in the heart of Bikita Heights. This weather station is complemented by Zaka weather station which falls just outside Turwi Basin on the south-west of the basin. The basin stretches from the Bikita-Muroyi highlands in the north to the confluence of Turwi and Save in the south.

Basin climate, vegetation, demographics and livelihoods

The climate of Turwi Basin is dry tropical, with very variable yet low annual rainfall averaging 450 to 650 mm/year (Mazvimavi, 2003; Fritz et al., 2003). Four seasons are clearly defined: a rainy season from mid- November to March, secondary rainy season (April- mid-May),a cold dry season (mid-May – mid-August and a hot dry season from late August - to late October. Severe dry spells are frequently experienced during the rainy season, especially in the lower drier part of the basin, resulting in crop failure (FAO, 2006). A large portion of Turwi Basin is characterized by high temperatures that sometimes exceed 30ºC in October and November and minimum temperatures of about 10ºC during winter from May to July (AWF, 2010). The rainy season lasts for around 100 days. Mean annual evaporation is approximately 2,000 mm (AWF, 2010). Consequently, deciduous dry savanna covers most of the basin.

Turwi Basin though is mainly characterised by a dense human settlement. The population of the basin as of August 2012 was estimated at 18,600 persons (ZimStat, 2012). A large proportion of the Turwi Basin falls in agro-ecological regions (IV) and(V) 5, with only the small Bikita-Muroyi highlands and their environs, falling in regions (II) and (III) (FAO, 2006) making it largely suitable for extensive livestock production with some drought tolerant crops such as sorghum, millet and rapoko also known as finger millet. The agro-ecological regions are according to the amount of rainfall received, with region I receiving more than 1,000 mm on average and region V receiving an average of 450 mm per annum (FAO, 2006). Agriculture is the main source of livelihood in the district but yields are usually low due to rainfall variability and drought (Muhonda, 2011). Mixed dry land crop and animal husbandry is the dominant activity but is affected by droughts and prolonged dry spells which cause crops to fail. The scenario painted above makes weather forecasting in the basin all the more important

Data collection: Sampling

Data were collected from six wards, three in each district, distributed thus one in each district's upper, middle and lower parts of the basin. The wards were chosen using purposive sampling and because of their proximity to each other (share common boundaries). Contiguous areas have similar environmental physiognomies and indigenous knowledge systems are localized knowledge domains**.** Settlements in the chosen wards date back to more than 100 years, because a few old people whose ages ranged between 80 and 92 years had been born in the area.

Data collection methods

Participatory Rural Appraisal (PRA) methods namely key informant interviews and Focus Group Discussions (FGDs) were used to collect data. Rainfall data and seasonal forecasting information for the *2015/2016* rainfall season were collected from basin community members and the Meteorological Services Department.

Key informant interviews

Key informants were chosen according to their expertise, social standing and length of stay in the basin. Selected village heads and those who had stayed in area for twenty five years or more were interviewed. Key informant interviews were conducted with two chiefs, eight village heads, twenty four ordinary basin residents and twelve AGRITEX and, DoM, EMA, Zaka Rural District Council Chairman and Bikita District Administrator's secretary.

Focus group discussions

FGDs are normally used to get in-depth qualitative information which cannot be obtained on a one-to-one basis. FGDs comprised of between 8 to 20 participants with ages ranging from 40 years and above and they were all selected on the basis that they have always stayed in the area, and are originally from the districts or they have stayed in the basin for at least 30 years, the standard period for data that is used by the World Meteorological Organization (WMO) http://www.wcc.nrcs.usda.gov/normals/30year_normals_data.htm.

Although women constituted the majority of older people interviewed, the researcher noted that they would not say much. A total of six focus group discussions were held in six wards - one in each upper, middle and lower basin parts of each of the two districts. FGDs were aimed at establishing consensus and clarifications on the most commonly used weather indicators, the role of forecasting in making decisions on which crops to be planted and perceptions on climate change.

Data analysis

Respondents were primarily categorized into age groups, from the young (18 to 25 years) to the elderly (at least 65 years). The younger age group may not have made observations as they would have spent some time attending school but were included to get to know whether they were observant as well as getting their perceptions. Interviews and FGDs were conducted in order to get the following key information:

- whether the particular individual has any knowledge on IKS on weather forecasting
- the type of forecast they find more reliable and why
- perceptions on climate change.

Results and discussion: weather forecasting indigenous knowledge and its use

This section presents the findings of the study. Findings on identification of indigenous weather indicators for both drought and normal to above normal seasons are presented. Indigenous Knowledge Systems (IKSs) are a body of knowledge or bodies of knowledge of the indigenous people of a particular geographical area that have survived on for a very long period of time (Mapara, 2009). Local weather and climate are assessed, predicted and interpreted by means of locally observed variables and experiences using combinations of plants, animals, insects and meteorological and astronomical indications

(Mugabe, 2010). This comes against the backdrop of the fact that IKSs have a number of physiognomies including those outlined in Table 1 below.

Table 1: Characteristics of IKSs

local or specific to a particular geography or micro-environment or ecosystem and folk people living there close to nature;
orally transmitted;
outcomes of informal experiments, intimate understanding of nature, and accumulation of generation-wise intellectual reasoning of day-to-day life experiences, generation-wise intellectual reasoning tested on "religious laboratory of survival;
originated through interactions and not at individual level;
empirical rather than theoretical or any abstract scientific knowledge;
functional or dynamic and hence constantly changing, discovered, lost and rediscovered in a new form (open-ended IK);
culturally embedded (close-ended) where separating the technical from nontechnical, rational to non-rational is problematic;
repeating with time (as because IK is both cultural and dynamic);
segmented into social clusters or asymmetrically distributed within a population, by gender and age;
shared by many and even by the global science

Source: Ellen and Harris, 1996

Use of IKSs by Turwi Basin communities

Farmers claimed to blend traditional farming knowledge with the advice they get from agricultural extension workers and local technology with development innovations. Thus farmers mix a variety of local forecasting knowledge such as environmental observations and spiritual traditions (Roncoli et al., 2002). In Turwi Basin, like in Makueni district in Kenya, communal farmers ordinarily depend on indigenous knowledge to predict the short-to-medium term weather conditions associated with the coming season just before the start of the farming season. Thus basin residents use the same signs from local weather patterns, state of fauna and flora, constellation of stars and as well as features from the physical environment, such as natural fires and mists in certain mountains, to forecast the nature of rains in a season (Speranza et al., 2009). As the season progresses, they acquire extra information through direct observation of atmospheric, biotic and meteorological indicators but may complement this with other local sources particularly listening to the weather forecast broadcast on radio or television.

Indigenous weather forecasting prediction indicators

Basin community members base their indigenous weather forecasts on a set of pointers. Three categories of indicators emerged *viz* biotic (plant phenology, animal and insect behaviour) and astronomic features and meteorological conditions all of which are used as weather indicators.

Biotic indicators

Plants

Fascinating knowledge relating to plants which has been used to predict weather has been passed on from one generation to the next. Indicators from flora can be in terms of tree conditions, flowering and subsequent bearing of fruit(s) by certain trees. Tree foliaging was also proffered by the basin community as a means to understand and predict weather. For them, the late foliaging of trees is indicative of late low rains which usually translate to a bad short rainfall season. Meanwhile the growing or appearance of new leaves (*pfumvuti*) on all trees is symptomatic of rains that are near and an upcoming wet rainy season. Early sprouting of new leaves means rains will come early that particular year and late foliaging suggests the converse. Risiro et al., (2012) observe that an assortment of biotic pointers are used to forecast weather changes in Chimanimani district in eastern Zimbabwe. A variety of trees like *msasa* (*brachystegia spiciforms*), *mutondo* (*julbernardia globiflora/ cordlya africana*) and *mupfuti* (*brachystegia bohemian*) change their morphology with season as they shade their leaves in the dry season and when the rainy season approaches, they grow new leaves (*pfumvuti*). In western countries, such information has been recorded for example dandelions (*Taraxacun officionale*), wild indigo (*Baptisia australis*) and tulips (*Tulipa gesneriana*), all of which fold their petals prior to rain (Alvera, 2013; Acharya, 2011).

Particular fruit trees are used as indicators of the impending drought or wet season. Thus *mushuku* (*Uapaca kirkiana*) and *muchakata* (*Parinari curatellifolia*) were highlighted as very good indicators. According to basin residents, an abundance of *mashuku* and *chakata* is symptomatic of a looming dry season and if the fruits are few, it is indicative of an imminent good rain season. This finding is consistent with findings made by Risiro et al., (2012) in Chimanimani District who added baobab/*muuyu* (*adansonia digitata*) while Alvera (2013) added *mushum*a (*dyspros mespiliformis*) and *nhunguru* (*flacourtia indica*) in Mbire District among other weather indicator fruits trees. The unusual bearing of a lot of fruit in a drought season is commonly believed to be God's way of providing people with food in times of scarcity.

In the Makueni district of Kenya people believe that when the acacia nicolita tree produces dense white flowers, lots of rain are anticipated and the rains usually fall within a few days (Speranza et al., 2009). Speranza et al., (2009) also found out that non-flowering or late flowering of acacia tree (*dombeya burgessiae/kirkii*), suggests drought conditions. In the Ismani and Mahenge wards in Tanzania, dense flowering of mango trees (*Mangifera indica*) and Mikuyu (*Ficus*) is an indicator of an oncoming drought season (Kijazi, 2012).

Animals, birds and insects

Animals and insects display certain behaviour(s) at the onset of and during the rainy season. The behaviour that animals, birds and insects exhibit, together with the sounds that they produce during the rainy season and before the onset of heavy rainfall is a type of warning. Turwi basin communities watch the nesting of *Ploceus intermedius* (weaver birds/ *machesa* and quelea birds /*ngozha*) in the early rainy season. If these birds build their nests high on the trees it is believed that rains will be normal to above normal but if their nests hang low on trees along the river bed it suggests a drought. This is akin to what Fulani herdsmen of Burkina Faso who pasture animals in uncultivated areas do (Roncoli et al., 2002). In Australia, when the lapwing bird (*Tatihari*) lays its eggs on the upper part of the field then good rains are expected and poor or no rains when it lays eggs on the lower part of the field (FAO, 1998).

The appearance of migratory birds like Abdim's stork (*shohori*/black and white stork) (*ciconia adminii*) and swallows (*nyenganyenga*) suggests that the rainy season has begun because they only appear when it has rained, a result which concurs with Risiro et al., (2012). When flocks of these birds are seen flying around in circles at low altitude it is said rain will fall any time soon perhaps in a day or two. Suffice to say these birds may be attracted by plenty of insects on which they feed which come along with the onset of a wet season. In addition, the continued presence of these migratory birds particularly in the early stages of the rainy season points towards a looming wet season ahead. The rain cuckoo (*kohwera*, *clamator glandarius*) is a highly ranked indicator of imminent rains. When it starts singing, rains are believed to be near and may fall the same day, within a few days or a week. Some respondents said the way the cuckoo sings indicates the expected time and amount of rainfall. If it sings like *kovira, kovira, tsvo*, above average rains will fall but if it just sings, *kovira, kovira* the rains will just be normal. This concurs with Shoko (2012) who found out that people in Mberengwa District, south-central Zimbabwe, rated the ground hornbill (*dendera*), *mukwasikwasi* (secretary bird)and the rain cuckoo, termites, cicadas and frogs 1, 2 and 3 respectively as the most frequently utilized weather indicators.

Sun spiders (jerrymunglums *solifugae/arachnida***)**, termites, cicadas and frogs featured prominently among the basin community as good weather forecasting indicators. The chirping of insects like cicadas (*nyezhe/cryptotympana postulata*) and crickets (*gryllidae/gryllus*) the whole day and night and frogs **(***xenopus laevis***)** croaking a lot indicates that temperatures are high (over 30^0C) and rains are expected within a day or two. Cicadas and crickets only appear when trees have foliaged. The movement around of sun spiders in large numbers and termites (*zviteza/ isoptera*) collecting grass and twigs for storage as food and closing their holes is interpreted to indicate high temperatures and imminent rains that are expected in a week or two (Makwara, 2013). These sustained high temperatures define their allied low pressure zones in the basin and country which precede the wet season at the beginning of the rainy season in November. When spiders are seen moving around in large numbers or closing their webs it is suggestive of the commencement of the rainy season. The arrival of butterflies is also said to indicate that the rainy season has begun. A large number of butterflies means there will be lots of worms which would have been laid and hatched during the ideal hot period.

Atmospheric weather forecasting indicators

Local people do not measure and record meteorological data as is done in formal weather and climate monitoring. Through observation based on life-long experience in their area, they can predict the average onset dates for rainfall and the expected amount(s) of rainfall. For basin residents, a delay in the onset of the rain season is an indicator that the season might not receive adequate rainfall (Speranza et al., 2009). Several authors (Kihupi et al., 2003; Speranza et al., 2009; Kijazi, 2012; Risiro et al., 2012) note that indigenous knowledge indicators from local weather range from temperature, humidity and wind conditions, the presence or absence of certain types of clouds, rainfall patterns and amounts. These weather indicators are also used in formal climate monitoring (Luseno et al., 2003). The most widely relied upon indicators are the timing, intensity and duration of the cold season/ spell and wind characteristics during the early part of the dry season from May to August (Makwara, 2013). In Manicaland province in Zimbabwe, people know that when wind blows from the eastern side bordering Mozambique, then the rain season is just 'around the corner' and if the wind is continuous, it 'tells' that more rains would come. In Masvingo province, people can predict rainfall patterns out of the southern blowing winds (Muguti and Maposa, 2012). Thus in Turwi Basin, good rains are anticipated if winds consistently blow in from the north-east or south east. A vast majority of the basin residents said that a particularly cold season precedes a very wet season though a few consider a very cold winter as a precursor to below normal rains. People also predict weather by observing the visible spectrum (*dziva remvura*/ halo phenomena) around the sun or moon and the rainbow (*murarabungu*). If the spectrum around the sun has a greater diameter than that around the moon, they predicted rainfall after a day or two. The appearance of rainbow during a rain event is said to be an indication that the rains would stop/would have stopped for a while.

Astronomic and meteorological indicators

Temperature, humidity and wind direction before or during the rainy season are also adopted by the basin community as indicators of both the timing, amount and intensity of rains that are expected to fall. These meteorological parameters are common in both IKS and SFCs (IDRC, 2010). Though no thermometers are used to measure how hot it is, people tell the heat intensity by for example the amount of sweat, breathlessness and the heat in the soil when one steps on the soil without shoes. Very high temperatures, causing breathlessness and sweating, even at night that sparks mirages during the day suggest that rains can fall within hours up to day or two. As the rainy season approaches, the wind direction can be used to tell the nature of the coming season. The period from end of October up to early November, light winds blow from almost all directions, causing whirlwind-like activity. Light rains can fall but usually the amount will be very little to start any agricultural activities. When winds blow consistently /continual from the north west/ south west direction until late November, rains will fall within a week but it is considered as an indication of below normal rains. Towards the end of November, south-easterly and north-easterly winds bring abundant rains, and this is usually a sign of a good season. If winds blow from north/ north-westerly direction, the rains will be light and is a sign of a bad season. In relation to clouds, if dark pregnant clouds that are accompanied by very strong winds, a storm is imminent, lots of rains expected. If natural fires occur in mountains such as Majuru or if mist forms in the either Chaziva mountain or in the Bikita-Muroyi highlands (e.g. Murove Hurumidza, Chemheni, Hozvi etc. then rains will be expected shortly. The accuracy of this indigenous observation can be as high as 50 per cent (FAO, 1998).

The time the Milky Way (*gwararakurumbi*) is seen in the sky is used to tell whether rains would be early or late. If the stars are seen early in the night towards end of October/ beginning of November, the rains will come early. Speranza et al., (2009) noted that astrological constellations such as the position of the sun and moon are also interpreted for the upcoming season by agro-pastoralists. The appearance of the stars in the sky could be used to predict seasons. The Milky Way changes its position in accordance with seasons and sun /moon halo appearance was regarded as a good indicator of coming rains within two weeks (Risiro et al., 2012).

The study of constellation of the stars is specialized to very few old people and is almost non-existent in the younger age groups (Risiro et al., 2012). The appearance of a halo around the moon and the stars, giving them a dim appearance was also noted to indicate that the rains are imminent. The respondents noted that the halo does not indicate how soon the rains are going to fall, but is merely a sign of impending rains. Dry spells can occur while the halo phenomenon is on. The new and old moon phases are associated with more rain, whereas the full moon phase is associated with little or no rains (Makwara, 2013).

Challenges of using IKS

In spite of all the usefulness of IKSs in weather and climate prediction, a number of researchers, (Githungo et al., 2009; Kijazi et al., 2012; Makwara, 2013) bemoan that the art of indigenous weather forecasting is under threat of disappearing due to lack of systematic documentation of the knowledge and lack of coordinated research to investigate the accuracy and reliability of IK forecasts. Although IKSs are localized and more adapted to the farmers' context, this knowledge is threatened by phenomena such as climate change, population growth and urbanization (Masinde and Bagula, 2012). The challenge in using IKS is what is considered to be a bench mark (normal). Therefore, it is imperative that more research be conducted to quantify the norms (Makwara, 2013). Just how many fruits, flowers butterflies and dragon flies are considered to be 'many', normal' or 'too little' is not actually defined by numerical values which are used by scientific methods. A number of documenting exercises have been done, but only a few existing studies on the contributions of IK to climate change research show that IK and science can complement each other (Luseno et al., 2003). Indicators used in weather prediction are localised and communication is mostly oral, limiting the applicability of IKSs over large areas (IDRC, 2010).

Integration of IKS and SCFs

Both IKS and SCFs have strengths and weaknesses and the major challenge is how to bring these two forms of knowledge together in a way that respects their values, while building upon their respective strengths (IDRC, 2010). Forecasts maybe more useful if ways are found to integrate local knowledge, which has enabled generations to live through severe droughts and floods into current management decision making strategies (Kihupi et al., 2003). Kihupi et al., (2003) further implore that if factors such as humidity, temperature and wind speed are responsible for changes observed or perceived by local people, then meteorological data from individual stations can be summarized into a mean value correlating with a derived index. Therefore, the study recommends the integration of IKSs and SCFs by basin residents to enhance their appreciation and understanding weather and climate, two fundamental variables that underpin food security

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